Area C, a large polygonal area approximately 368 ha (909 ac) located adjacent to the south side of State Route (SR) 240 and centered approximately on the intersection of Beloit Avenue and SR 240, has been identified as a borrow-use area for the fine-grade silt loam and coarse-grade basalt needed to cap the LLBGs (Figure 4.1).

4.3 Meteorology and Air Quality

Air resources addressed in this section include climate and meteorology, atmospheric dispersion, and ambient air quality.

4.3.1 Climate and Meteorology

The Hanford Site is categorized as a mid-latitude semiarid region. Summers are warm and dry, while winters are cool with occasional precipitation. Intense heating during the day and nocturnal cooling produce large diurnal temperature variations. The Cascade Mountain range, beyond Yakima to the west, greatly influences the climate of the Hanford area by means of its rain shadow effect. The Cascade Mountains limit the Pacific Ocean maritime influence by blocking the passage of frontal systems and causing less rain and cloud-cover on the lee (east) side of the mountains. This mountain range also serves as a source of cold air drainage with a considerable effect on the wind regime at the Hanford Site.

Climatological data for the Hanford Site are compiled at the Hanford Meteorology Station (HMS). The HMS is located just outside the northeast corner of 200 West Area and about 4 km (3 mi) west of the 200 East Area. Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau. Meteorological measurements have been made at the HMS since late 1944. Prior to the establishment of the HMS, local meteorological observations were made at the old Hanford townsite (1912 through late 1943) and in Richland (1943-1944). A climatological summary for Hanford is provided in Hoitink et al. (2002). To accurately characterize meteorological differences across the Hanford Site, the HMS operates a network of automated monitoring stations. These stations, which currently number 30, are located throughout the site and in neighboring areas (Figure 4.6). A 124-m (408-ft) instrumented meteorological tower operates at the HMS, Station 21. A 61-m (200-ft) instrumented tower operates at each of the 100-N, 300, and 400 Area meteorology-monitoring sites. Most of the other network stations utilize short-instrumented towers with heights of about 9 m (30 ft). Instrumentation on each tower is described in Table 4.1. Data are collected and processed at each monitoring site and key information is transmitted to the HMS every 15 minutes. This monitoring network has been in full operation since the early 1980s.

Wind. Wind data at the HMS are collected at 2.1 m (7 ft) above the ground and at the 15.2-, 61.0-, and 121.9-m (50-, 200-, and 400-ft) levels on the 124-m (408-ft) tower. Each of the three 61-m (200-ft) towers has wind-measuring instrumentation at the 10-, 25-, and 60-m (33-, 82-, and 197-ft) levels. The short towers measure winds at 9.1 m (30 ft) above ground level.

Prevailing wind directions near the surface on the Hanford 200 Area Plateau are from the northwest in all months of the year (Figure 4.7). Winds from the northwest occur most frequently during the winter and summer. Winds from the southwest also have a high frequency of occurrence on the 200 Area Plateau. During the spring and fall, the frequency of winds from the southwest increases and winds from the northwest correspondingly decrease.

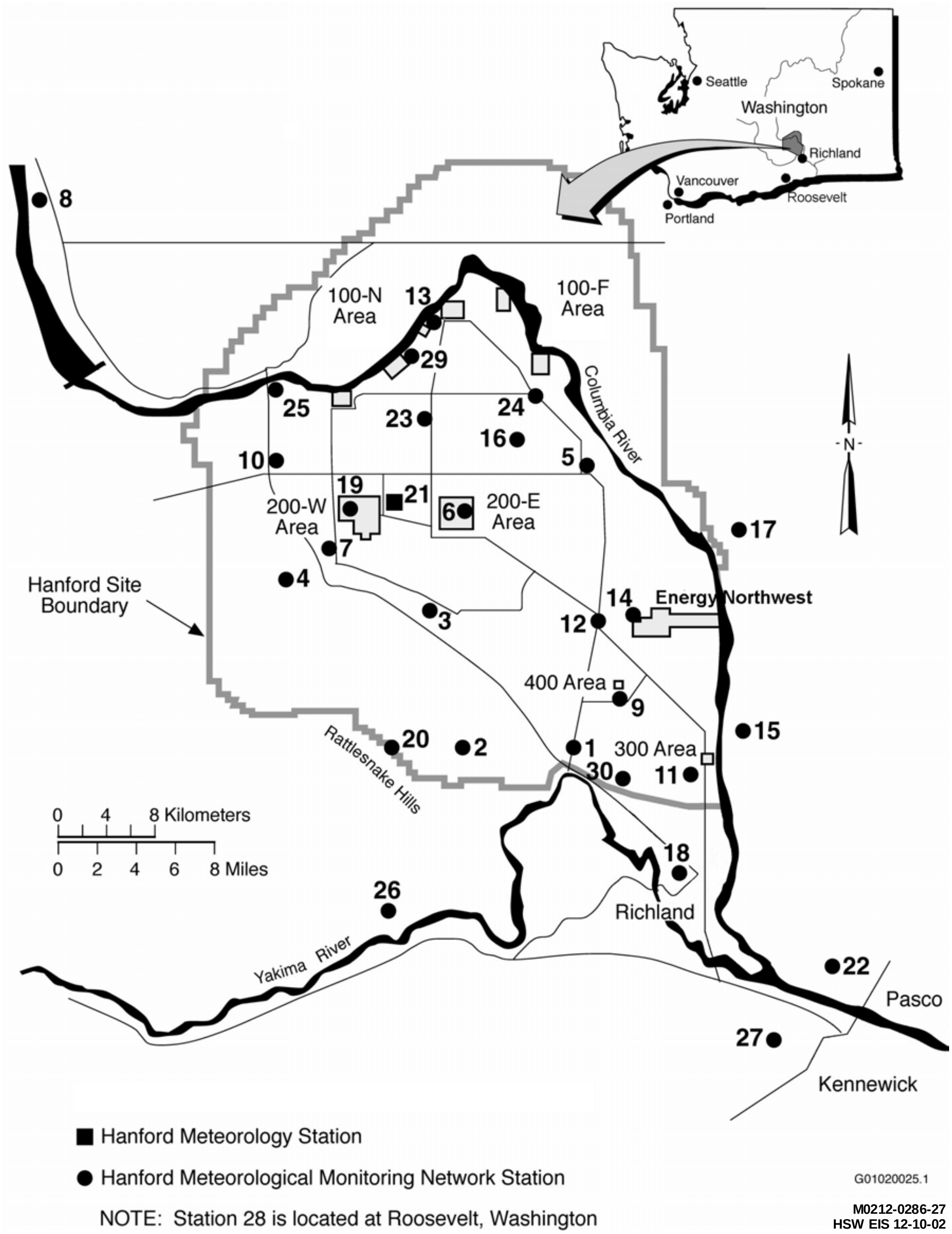

Figure 4.6. Hanford Meteorological Monitoring Network (after Hoitink et al. 2002)

Table 4.1. Station Numbers, Names, and Meteorological Parameters for Each Hanford Meteorological Monitoring Network Site (Hoitink et al. 2002)

Site Number	Site Name	Meteorological Parameter
1	Prosser Barricade	WS, WD, T, P
2	Emergency Operations Center	WS, WD, T, P
3	Army Loop Road	WS, WD, T, P
4	Rattlesnake Springs	WS, WD, T, P
5	Edna	WS, WD, T
6	200 East Area	WS, WD, T, P, AP
7	200 West Area	WS, WD, T, P
8	Beverly	WS, WD, T, P
9	Fast Flux Test Facility (61 m or 200 ft)	WD, T, TD, DP, P, AP
10	Yakima Barricade	WS, WD, T, P, AP
11	300 Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
12	Wye Barricade	WS, WD, T, P
13	100-N Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
14	Energy Northwest (Supply System)	WS, WD, T, P
15	Franklin County	WS, WD, T
16	Gable Mountain	WS, WD, T
17	Ringold	WS, WD, T, P
18	Richland Airport	WS, WD, T, AP
19	Plutonium Finishing Plant	WS, WD, T, AP
20	Rattlesnake Mountain	WS, WD, T, P
21	Hanford Meteorology Station (125 m or 410 ft)	WS, WD, T, P, AP
22	Tri-Cities Airport	WS, WD, T, P
23	Gable West	WS, WD, T
24	100-F Area	WS, WD, T, P
25	Vernita Bridge	WS, WD, T
26	Benton City	WS, WD, T, P
27	Vista	WS, WD, T, P
28	Roosevelt, Washington[(a)]	WS, WD, T, P, AP
29	100-K Area	WS, WD, T, P, AP
30	HAMMER	WS, WD, T

Legend:

AP - atmospheric pressure
DP - dew point temperature
P - precipitation
T - temperature
TD - temperature difference (between 10-m and 60-m tower levels)
WD - wind direction
WS - wind speed

(a) Roosevelt is located on the Columbia River 92 km (57 mi) west/southwest of the site.

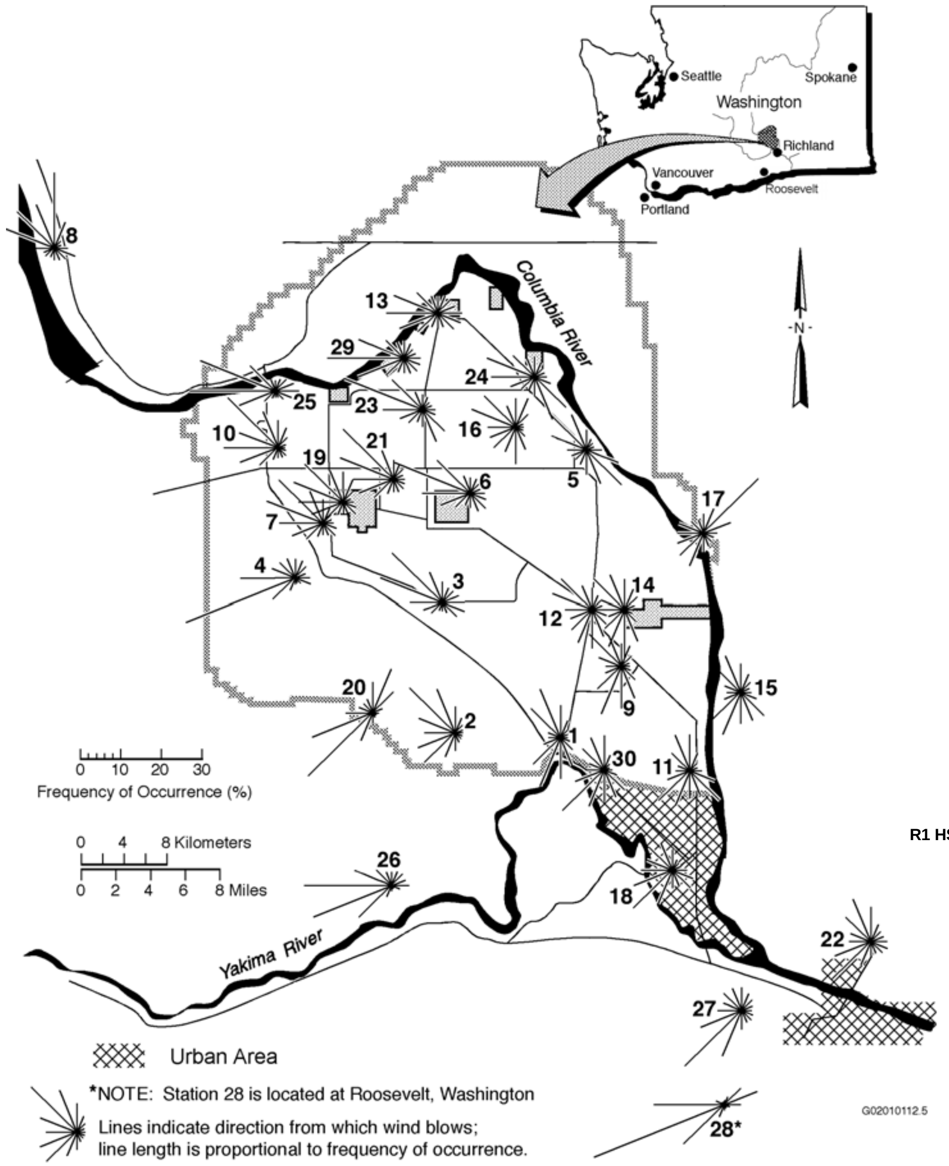

Figure 4.7. Wind Roses at the 9.1-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982 to 2001 (after Hoitink et al. 2002)

Monthly and annual joint-frequency distributions of wind direction versus wind speed for the HMS are reported by Hoitink et al. (2002). Monthly average wind speeds at 15.2 m (50 ft) above the ground are lower during the winter months, averaging 2.7 to 3.1 m/s (6 to 7 mph), and highest during the summer, averaging 3.6 to 4.0 m/s (8 to 9 mph). The highest wind speeds at the HMS are usually associated with flow from the southwest. However, the summertime drainage winds from the northwest frequently exceed speeds of 13 m/s (30 mph). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease toward the southeast across the Hanford Site.

Surface features have less influence on winds aloft than winds near the surface. However, substantial spatial variations are found in the wind distributions across Hanford at 61 m (200 ft) above ground level (Figure 4.8). For releases at greater heights, the most representative data may come from the closest representative 61-m (200-ft) tower rather than the nearest 9.1-m (30-ft) tower.

Table 4.2 presents information on number of days, by month and annually, with wind gusts ≥11 m/s (25 mph) and 16 m/s (35 mph) for the HMS. Table 4.3 presents monthly and annual prevailing wind directions, average wind speeds, and peak wind gusts at the HMS, 1945 through 2001.

Temperature and Humidity. Monthly averages and extremes of temperature, dew point, and humidity are presented by Hoitink et al. (2002). Based on data collected from 1946 through 2001, the average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July. The highest winter monthly average temperatures were 6.9°C (44°F) in February 1958 and February 1991, and the lowest average monthly temperature was -11.1°C (12°F) in January 1950. The highest monthly average temperature was 27.9°C (82°F) in July 1985, and lowest summer monthly average temperature was 17.2°C (63°F) in June 1953. Ranges of daily maximum temperatures vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July. The record maximum temperature is 45°C (113°F), and the record minimum temperature is -31°C (-23°F).

Relative humidity/dew point temperature measurements are made every 15 minutes at the 200 Area HMS (Station 21). The annual average relative humidity at the HMS is 55 percent. It is highest during the winter months, averaging about 76 percent, and lowest during the summer, averaging about 36 percent. The annual average dewpoint temperature at the HMS is 1°C (34°F). In the winter the dewpoint temperature averages about -3°C (27°F), and in the summer it averages about 6°C (43°F).

Precipitation. Precipitation measurement records have been kept at the HMS since 1945. Average annual precipitation at the HMS is 17 cm (6.8 in.). In the wettest year on record, 1995, 31.3 cm (12.3 in.) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3 in.) was measured. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Average snowfall ranges from 0.25 cm (0.1 in.) in October to a maximum of 13.2 cm (5.2 in.) in December and decreases to 0.8 cm (0.3 in.) in March. Snowfall accounts for about 38 percent of all precipitation from December through February.

Fog and Visibility. Fog has been recorded during every month of the year on the 200 Area Plateau; however, 89 percent of the occurrences are from November through February, with less than 3 percent from April through September. Fog is reported any time horizontal visibility is reduced to 9.6 km (6 mi) or less because of the suspension of water droplets in the surface layer of the atmosphere. Dense fog is reported when horizontal visibility is reduced to 0.4 km (0.25 mi) or less.

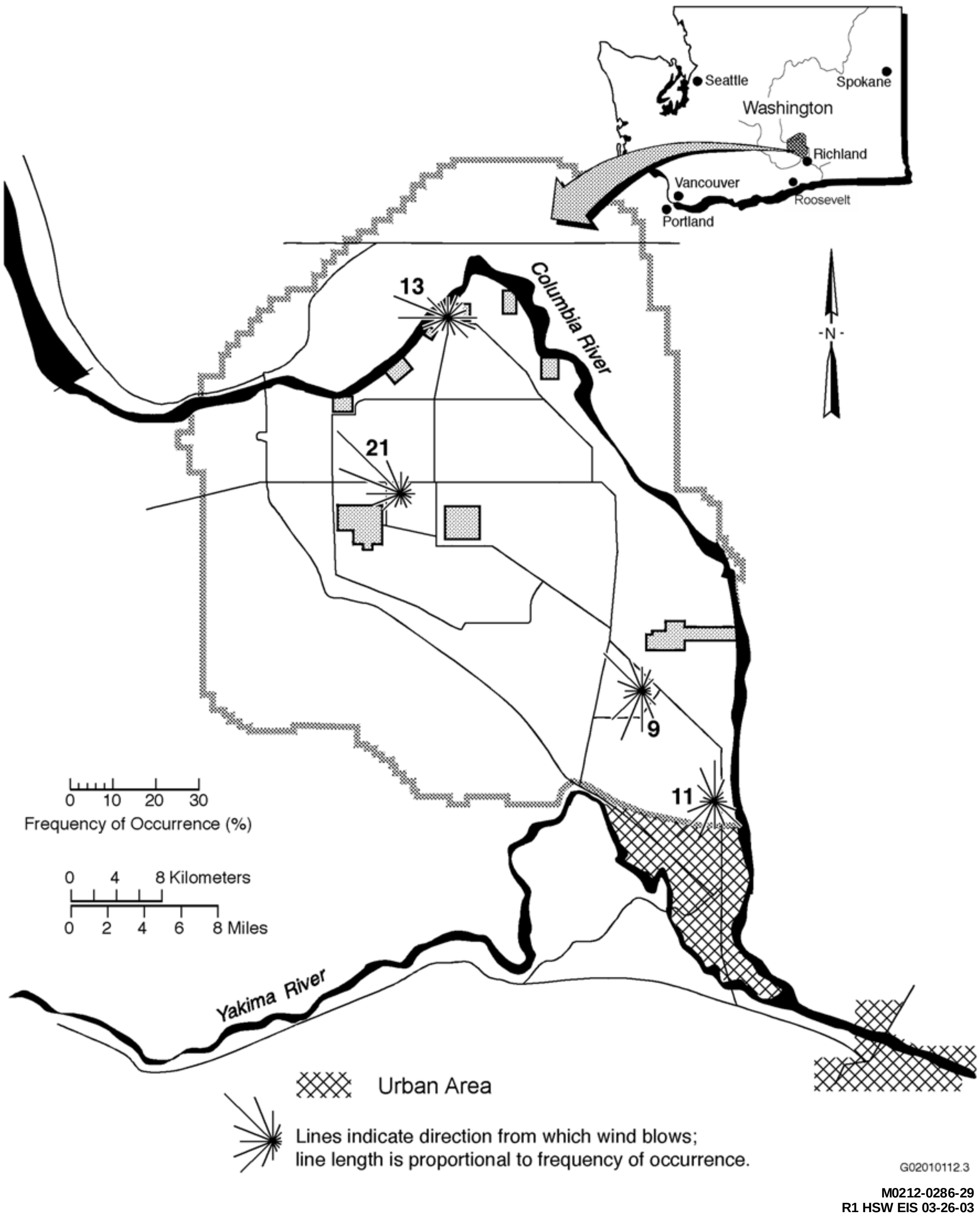

Figure 4.8. Wind Roses at the 60-m (197-ft) Level of the Hanford Meteorological Monitoring Network, 1986 to 2001 (after Hoitink et al. 2002)

Table 4.2. Number of Days with Peak Gusts Above Specific Thresholds at 15-m (50-ft) Level, 1945 through 2001 (Hoitink et al. 2002)

	Days with Peak Gusts ≥11 m/s (25 mph)					Days with Peak Gusts ≥16 m/s (35 mph)				
Month	**Avg**	**Max**	**Year**	**Min**	**Year**	**Avg**	**Max**	**Year**	**Min**	**Year**
January	7.6	21	1953	0	1985[a]	4.0	14	1953	0	1985[a]
February	8.6	17	1976[a]	2	1952[a]	3.7	14	1976	0	2001[a]
March	13.0	21	1977	4	1992	5.4	14	1997	0	1992
April	16.9	26	1954	8	1946	6.2	12	1972	1	1967
May	18.7	26	1978	9	1945	6.1	10	2000[a]	0	1957
June	19.6	26	1963	11	1950[a]	6.2	12	1973	1	1982
July	19.5	26	1995	11	1955	5.5	11	1994[a]	1	1982[a]
August	15.8	24	2000	7	1945	4.1	12	1996	0	1978[a]
September	11.1	17	1971	7	1975[a]	3.3	7	2001[a]	0	1975
October	8.9	17	1985[a]	3	1987[a]	3.2	11	1997	0	1993[a]
November	8.3	16	1990	0	1979	3.8	10	1998	0	1997[a]
December	7.6	15	1968	0	1985	4.3	11	1957	0	1985[a]
Annual	155.8	192	1999	123	1952	55.9	83	1999[a]	31	1978
(a) Most recent of multiple occurrences.										

Table 4.3. Monthly and Annual Prevailing Wind Directions, Average Speeds, and Peak Gusts at 15-m (50-ft) Level, 1945 through 2001 (Hoitink et al. 2002)

Month	Prevailing Direction	Average Speed (mph)	Highest Average (mph)	Year	Lowest Average (mph)	Year	Peak Gusts Speed (mph)	Peak Gusts Direction	Peak Gusts Year
January	NW	6.3	10.3	1972	2.9	1985	80	SW	1972
February	NW	7.1	11.1	1999	4.6	1963	65	SW	1971
March	WNW	8.2	10.7	1977[a]	5.9	1958	70	SW	1956
April	WNW	8.8	11.1	1972[a]	7.4	1989[a]	73	SSW	1972
May	WNW	8.8	10.7	1983	5.8	1957	71	SSW	1948
June	NW	9.1	10.7	1983[a]	7.7	1950[a]	72	SW	1957
July	NW	8.6	10.7	1983	6.8	1955	69	WSW	1979
August	WNW	8.0	9.5	1996	6.0	1956	66	SW	1961
September	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953
October	NW	6.6	9.1	1946	4.4	1952	72	SW	1997
November	NW	6.3	10.0	1990	2.9	1956	67	WSW	1993
December	NW	6.0	8.3	1968	3.3	1985	71	SW	1955
Annual	NW	7.6	8.8	1999	6.2	1989	80	SW	Jan-72
(a) Also in earlier years.									

Other phenomena causing restrictions to visibility (visibility less than or equal to 9.6-km [6 mi]) include dust, blowing dust, and smoke from field burning. Few such days occur; an average of 5 d/yr have dust or blowing dust and <1 d/yr has reduced visibility from smoke.

Severe Weather. The average occurrence of thunderstorms on the 200 Area Plateau is 10 per year. Using the National Weather Service (NWS) criteria for classifying a thunderstorm as severe (that is, hail with a diameter ≥19 mm [3/4 in.] or wind gusts of ≥25.9 m/s [58 mph]), only 1.9 percent of all thunderstorm events surveyed at the HMS have been "severe" storms, and they met the NWS criteria based on their wind gusts. High-speed winds at Hanford are more commonly associated with strong cold frontal passages. In rare cases, intense low-pressure systems can generate winds of near hurricane force. Estimates of the extreme winds, based on peak gusts, are given by Hoitink et al. (2002).

The National Climatic Data Center maintains a database that provides information on the incidence of tornados reported in each county in the United States. (This database can be accessed via the Internet at http://www.ncdc.noaa.gov/ol/climate/severeweather/extremes.html.) This database reports that in the 10 counties closest to the Hanford Site (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla counties in Washington, Umatilla, and Morrow counties in Oregon), only 18 tornadoes were recorded from 1950 through March 2001. Of these, 12 tornadoes had maximum wind speeds estimated to be in the range of 18 to 32 m/s (40 to 72 mph), 3 had maximum wind speeds in the range of 33 to 50 m/s (73 to 112 mph), and 3 had maximum wind speeds in the range of 51 to 71 m/s (113 to 157 mph). No deaths or substantial property damage were associated with any of these tornadoes.

Ramsdell and Andrews (1986) report that for the area in which the Hanford Site is located (a 5° block centered at 117.5° west longitude and 47.5° north latitude), the expected path length of a tornado is 7.6 km (4.7 mi). The expected width is 95 m (312 ft), and the expected area is about 1.5 km^2 (0.6 mi^2). The estimated probability of a tornado striking any point at Hanford, also from Ramsdell and Andrews (1986), is 9.6×10^{-6}/yr. The probabilities of extreme winds associated with tornadoes striking a point can be estimated using the distribution of tornado intensities for the region. These probability estimates are given in Table 4.4.

Table 4.4. Estimate of the Probability of Extreme Winds Associated with Tornadoes Striking a Point at Hanford (Ramsdell and Andrews 1986)

Wind Speed		Probability Per Year
(m/s)	(mph)	
28	62	2.6×10^{-6}
56	124	6.5×10^{-7}
83	186	1.6×10^{-7}
111	249	3.9×10^{-8}

4.3.2 Atmospheric Dispersion

Atmospheric dispersion is defined as the transport and diffusion of gases and particles within the atmosphere. It is a function of wind speed, duration and direction of wind, mixing depth, and the intensity of atmospheric turbulence (wind motions at very small time scales that act to disperse gas and particles rather than transporting them downwind). Atmospheric turbulence is not measured directly at the Hanford Site; instead, the impact of turbulence on atmospheric dispersion is characterized using atmospheric stability. Atmospheric stability describes the thermal stratification or vertical temperature structure of the atmosphere. Generally, six or seven different classes of atmospheric stability are used to describe the atmosphere. These classes range from extremely unstable (when atmospheric turbulence is greatest) to extremely stable (when atmospheric mixing is at a minimum and wind speeds are low). When the atmosphere is unstable, pollutants can rapidly diffuse through a wide volume of the atmosphere. When the atmosphere is stable, pollutants will diffuse much more slowly in a vertical direction. Horizontal dispersion may be limited during stable conditions; however, plumes may also fan out horizontally during stable conditions, particularly when the wind speed is low. Most major pollutant incidents are associated with stable conditions when inversions can trap pollutants near the ground.

Favorable dispersion conditions are most common in the summer when neutral and unstable stratification is present—about 56 percent of the time (Stone et al. 1983). Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter, when moderately to extremely stable stratification is present, about 66 percent of the time (Stone et al. 1983). Low dispersion conditions also occur periodically for surface and low-level releases in all seasons from about sunset to about an hour after sunrise, as a result of ground-based temperature inversions and shallow mixing layers. Occasionally, extended periods of poor dispersion conditions are associated with stagnant air in the stationary high-pressure systems that occur primarily during the winter months (Stone et al. 1983).

Stone et al. (1972) estimated the probability of extended periods of poor dispersion conditions. The probability of an inversion, once established, persisting more than 12 hr varies from a low of about 10 percent in May and June to a high of about 64 percent in September and October. These probabilities decrease rapidly when the duration of the inversion is more than 12 hr. Table 4.5 summarizes the probabilities associated with extended surface-based inversions.

Many simple dispersion models use the joint frequency distribution of atmospheric stability, wind speed, and wind direction to compute diffusion factors for chronic and acute releases. Joint frequency distributions of atmospheric stability, wind speed, and transport direction for the measurements taken in the 200 Areas at 9.1 m (30 ft) and 60 m (197 ft) are found in Appendix F, Tables F.34 and F.35. The values in the joint frequency distributions represent the percentage of the time that pollutants would initially be transported toward the direction listed[a] (for example, S, SSW, SW).

(a) The transport direction and the wind direction are different methods of reporting the same basic information. Wind direction and transport direction are always out of phase by 180°.

Table 4.5. Percent Probabilities for Extended Periods of Surface-Based Inversions (based on data from Stone et al. 1972)

Months	Inversion Duration		
	12 hr	24 hr	48 hr
	Percent		
January-February	54.0	2.5	0.28
March-April	50.0	<0.1	<0.1
May-June	10.0	<0.1	<0.1
July-August	18.0	<0.1	<0.1
September-October	64.0	0.11	<0.1
November-December	50.0	1.2	0.13

4.3.3 Air Quality

The U.S. Environmental Protection Agency (EPA) has issued regulations (40 CFR 50) setting national ambient air quality standards. Individual states have the primary responsibility for assuring that air quality within the state meets the national ambient air quality standards through state implementation plans (SIP) that are approved by EPA. Areas that meet ambient air quality standards are said to be in attainment. Areas that do not meet one or more ambient air quality standards are designated as non-attainment areas. The Hanford Site is in attainment or unclassified with respect to national ambient air quality standards (40 CFR 81.348). Table 4.6 summarizes the relevant air quality standards (federal and supplemental Washington State standards). The nearest non-attainment areas to the Hanford Site are the Wallula area, located approximately 30 km (20 mi) southeast of the site, and Yakima, located approximately 70 km (44 mi) east of the site. Wallula and Yakima are non-attainment areas for PM_{10} (40 CFR 81.348).

Ambient air quality standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards). Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access (40 CFR 50.1). EPA has issued ambient air quality standards for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) and 2.5 micrometers ($PM_{2.5}$), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods. The averaging periods vary from 1 hr to 1 yr, depending on the pollutant.

Table 4.6. Federal and Washington State Ambient Air Quality Standards[a] (after Neitzel 2002a)

Pollutant	National Primary	National Secondary	Washington State
Total Suspended Particulates			
Annual geometric mean	NS[b]	NS	60 μg/m^3
24-hr average	NS	NS	150 μg/m^3
PM_{-10}			
Annual arithmetic mean	50 μg/m^3	50 μg/m^3	50 μg/m^3
24-hr average	150 μg/m^3	150 μg/m^3	150 μg/m^3
$PM_{2.5}$			
Annual arithmetic mean	15 μ/m^3	15 μg/m^3	NS
24-hr average	65 μg/m^3	65 μg/m^3	
Sulfur Dioxide			
Annual average	0.03 ppm	NS	0.02 ppm
	(≅80 μg/m^3)		(≅50 μg/m^3)
24-hr average	0.14 ppm	NS	0.10 ppm
	(≅365μg/m^3)		(≅260 μg/m^3)
3-hr average	NS	0.50 ppm	NS
		(≅1.3 mg/m^3)	
1-hr average	NS	NS	0.40 ppm
			(≅1.0 mg/m^3)[c]
Carbon Monoxide			
8-hr average	9 ppm	9 ppm	9 ppm
	(≅10 mg/m^3)	(≅10 mg/m^3)	(≅10 mg/m^3)
1-hr average	35 ppm	35 ppm	35 ppm
	(≅40 mg/m^3)	(≅40 mg/m^3)	(≅40 mg/m^3)
Ozone			
8-hr average	0.08 ppm	0.08 ppm	NS
	(~157 μg/m^3)	(~157 μg/m^3)	
1-hr average	0.12 ppm	0.12 ppm	0.12 ppm
	(≅235 μg/m^3)	(≅235 μg/m^3)	(≅235 μg/m^3)
Nitrogen Dioxide			
Annual average	0.053 ppm	0.053 ppm	0.053 ppm
	(≅100 μg/m^3)	(≅100 μg/m^3)	(≅100 μg/m^3)
Lead			
Quarterly average	1.5 μg/m^3	1.5 μg/m^3	1.5 μg/m^3
Radionuclides	[d]	NS	[e]
Fluorides			
12-hr average	NS	NS	3.7 μg/m^3
24-hr average			2.9 μg/m^3
7 day average			1.7 μg/m^3
30 day average			0.84 μg/m^3

Abbreviations: ppm = parts per million; μg/m^3 = micrograms per cubic meter; mg/m^3 = milligrams per cubic meter.

(a) Source: 40 CFR 50 and WAC 173-470 – 173-481. Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year unless otherwise noted. Particulate pollutants are in micrograms per cubic meter. Gaseous pollutants are in parts per million and equivalent microgram (or milligram) per cubic meter.

(b) NS = no standard.

(c) 0.25 ppm not to be exceeded more than twice in any 7 consecutive days (WAC 246-247; 40 CFR 61).

(d) Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr (40 CFR 61 Subpart H).

(e) Emissions of radionuclides in the air shall not cause a maximum accumulated dose equivalent of more than 25 mrem/yr to the whole body or 75 mrem/yr to a critical organ of any member of the public (WAC 173-480) or a TEDE of 10 mrem/yr (40 CFR 61 Subpart H; WAC 267-247), whichever is more stringent. Doses due to radon-220, radon-222, and their respective decay products are excluded from these limits.

In 1994, DOE and EPA signed the Federal Facility Compliance Agreement for Radionuclides National Emission Standards for Hazardous Air Pollutants (NESHAPs) (EPA 1994). This agreement provides a compliance plan and schedule designed to bring the Hanford Site into compliance with Clean Air Act requirements under 40 CFR 61, Subpart H, for the continuous measurement of emissions from applicable airborne emissions sources. The Hanford Site air emissions are below the regulatory standard of 10 mrem/yr (Poston et al. 2002). Radioactive air emissions are also regulated by Washington State. Hanford Site radionuclide air emissions are below limits set forth by permits issued by the State of Washington (Table 4.6).

State and local governments have the authority to impose standards for ambient air quality that are stricter than the national standards. Washington State has established more stringent standards for sulfur dioxide (WAC 173-474). In addition, Washington State has established standards for total suspended particulates (Washington State Administrative Code [WAC 173-470]), radionuclides (WAC 246-247), and fluorides (WAC 173-481). The Washington State standards for carbon monoxide, nitrogen dioxide, PM_{10}, and lead are identical to the national standards. The Hanford Site is in compliance with the Washington State ambient air quality standards (see Table 4.6).

4.3.3.1 Emissions of Non-Radiological Pollutants

Non-radiological pollutants are emitted mainly from power-generating and chemical-processing facilities located on the Hanford Site. Table 4.7 summarizes the year 2001 airborne emission rates of non-radiological constituents from these facilities. The 100, 400, and 600 Areas have no non-radioactive emission sources of regulatory concern (Poston et al. 2002).

4.3.3.2 Radiological Air Quality

Air emissions that may contain radioactive constituents are monitored at the Hanford Site. Samples are analyzed for gross alpha and gross beta activity, as well as for selected radionuclides.

Radioactive airborne emissions during 2001 (the most recent year for which data are published) originated in the 100, 200, 300, 400, and 600 Areas. The 100 Area emissions originated from normal evaporation from K Basins (irradiated fuel stored in two water-filled storage basins), the Cold Vacuum Drying Facility in the 100-K Area, and a low-level radiochemistry laboratory. The 200 Area emissions originated from the Plutonium Finishing Plant, T Plant Complex, 222-S Laboratory, tank farms, waste evaporators, and the inactive PUREX Plant. Emissions from the 300 Area originated from the 324 Waste Technology Engineering Laboratory, 325 Applied Chemistry Laboratory, 327 Post-Irradiation Laboratory, and 340 Vault and Tanks. The 400 Area emissions originated from the FFTF, and the Maintenance and Storage Facility. Emissions from the 600 Area originated at the Waste Sampling and Characterization Facility. Releases from this facility are considered as being in the 200 West Area for release and dose-modeling purposes (Poston et al. 2002). A summary of radiological air emissions is provided in Table 4.8.

Table 4.7. Non-Radioactive Constituents Emitted to the Atmosphere for the Year 2001 (Poston et al. 2002)

Constituent	Emission, kg (lb)	
	200 Areas	300 Area
Particulate matter	790 (1,742)	610 (1,345)
Nitrogen oxides	25,000 (55,115)	4500 (9921)
Sulfur oxides	2700 (5952)	35 (77)
Carbon monoxide	17,000 (37,478)	11,000 (24,251)
Lead	0.47 (1.0)	0.0 (0.0)
Volatile organic compounds[a, b]	5800 (12,787)	700 (1543)
Ammonia[c]	12,000 (26,455)	NE[d]
Other toxic air pollutants[c]	2600 (5732)	NE

(a) The estimate of volatile organic compound emissions does not include emissions from certain laboratory operations.
(b) Produced from burning fossil fuels for steam generation and electrical generators, calculated estimates from the 200 East and 200 West Area tank farms, and operation of the 242-A Evaporator and the 200 Areas Effluent Treatment Facility.
(c) Releases are from the 200 East Area tank farms, 200 West Area tank farms, and operation of the 242-A Evaporator, and the 200 Areas Effluent Treatment Facility.
(d) NE = no emissions.

The potential air pathway dose from stack emissions to a maximally exposed individual was calculated to be 0.048 mrem/yr, which represents less than 0.5 percent of the EPA standard (Poston et al. 2002).

4.3.4 Background Radiation

For the year 2001, the average external dose rate near the Hanford Site boundary was measured at 91 ± 4 mrem/yr using thermoluminescent dosimeters (Poston et al. 2002). Similarly for communities nearby the site, such as Richland, Pasco, Kennewick, Mattawa, Othello, Basin City, and Benton City, the average dose rate was measured at 80 ± 3 mrem/yr. The average external dose rate measured for distant communities, such as Toppenish and Yakima, was 72 ± 2 mrem/yr. The national average for external radiation dose from naturally occurring sources is about 55 mrem/yr (NCRP 1987), but it varies substantially with elevation and geological conditions. At a given location, the annual variation in external dose rate is on the order of 5 mrem. External radiation is but one part of total effective dose equivalent received from naturally occurring sources. The information presented here are representative of the external dose rate, excluding radon and presence of radionuclides internal to the body. Naturally occurring sources of ionizing radiation include primordial radionuclides, such as potassium-40 and the uranium series; cosmogenic radionuclides, such as carbon-14 and tritium; and cosmic radiation. The radionuclides are present in varying amounts in nearly all media including soil, air, water, food, biota, and humans.

Table 4.8. Radionuclides Emitted to the Atmosphere at the Hanford Site, 2001 (Poston et al. 2002)

Radionuclide	Half-Life in Years	Emission, Ci [a]				
		100 Areas	200 East Area	200 West Area	300 Area	400 Area
Tritium (as HT)[b]	12.3 yr	NM[c]	NM	NM	8.9E+01	NM
Tritium (as HTO)[b]	12.3 yr	NM	NM	NM	2.4E+02	3.1E-01
Cobalt-60	5.3 yr	3.0E-08	ND[d]	ND	ND	NM
Strontium-90	29.1 yr	9.0E-06	1.2E-04[e]	1.4E-04[e]	2.8E-05[e]	NM
Technetium-99	2.13×10^5 yr	NM	NM	NM	ND	NM
Antimony-125	2.77 yr	ND	ND	ND	ND	NM
Iodine-129	1.6×10^7 yr	NM	8.4E-04	NM	NM	NM
Cesium-137	30 yr	2.1E-05	1.2E-04	5.5E-05	3.7E-06	7.5E-06[f]
Uranium-234	2.4×10^5 yr	NM	NM	NM	1.5E-10	NM
Uranium-238	4.5×10^9 yr	NM	NM	NM	3.3E-11	NM
Plutonium-238	87.7 yr	1.5E-07	4.4E-08	4.5E-06	7.7E-09	NM
Plutonium-239, 240	2.4×10^4 yr	1.2E-06	2.1E-06[g]	2.6E-04[g]	1.9E-07[g]	6.9E-07[g]
Plutonium-241	14.4 yr	1.2E-05	3.1E-06	1.4E-04	NM	NM
Americium-241	432 yr	9.5E-07	2.6E-06	4.2E-05	2.5E-08	NM
Americium-243	7380 yr	NM	NM	NM	ND	NM

(a) 1 Ci = 3.7 E+10 Bq;
(b) HTO = tritiated water vapor; HT = elemental tritium.
(c) NM = not measured;
(d) ND = not detected (i.e., either the radionuclide was not detected in any sample during the year or the average of all the measurements for that given radionuclide or type of radioactivity made during the year was below background levels).
(e) This value includes gross beta release data. Gross beta and unspecified beta results assumed to be strontium-90 for dose calculations.
(f) This value includes gross alpha release data. Gross alpha and unspecified alpha results assumed to be plutonium-239/240 for dose calculations.
(g) Analyses were conducted for gross alpha activity, but none was detected. If detected, it would have been assumed to be plutonium-239/240 for dose calculations.

4.4 Geologic Resources

Geologic considerations for the Hanford Site include topography and geomorphology, stratigraphy, soil characteristics, and seismicity. This section, which provides an overview of the Hanford Site subsurface environment, focuses primarily on the 200 Area Plateau, located in the center of the site.

4.4.1 Topography and Geomorphology

The sites associated with the Hanford Solid Waste Program are located on a broad flat area of the Hanford Site commonly referred to as the Central Plateau. The Central Plateau is within the Pasco Basin, a topographic, structural depression in the southwest corner of the Columbia Basin physiographic subprovince. This subprovince is characterized by generally low-relief hills with deeply carved river